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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
08/825,360	03/28/1997	MARVIN LIAO	761/P7US/CVD	9780

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EXAMINER	
QUACH, TUAN N	
ART UNIT	**PAPER NUMBER**
2814	

DATE MAILED: 11/30/2001

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 08/825,360	Applicant(s) LIAO ET AL.	
	Examiner Tuan Quach	Art Unit 2814	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *26 October 2001* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *21-23 and 25-53* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *21-23 and 25-53* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claims 21-23 and 25-53 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

"said layer of refractory material" in claim 21 lines 9-10 and claim 48 lines 7-8 lacks antecedent basis and is inconsistent with the previously recited refractory metal.

Claims 21-23 and 25-53 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. The said subject matter corresponds to the amended feature in claim 21 step c) and claim 48 step c) taken in the context of claims 21 and 48. There is no description of and support for the claimed limitations regarding the metal nitride layer having thickness greater than that of the refractory metal, when the metal nitride is of the range as claimed in step b) of claim 21 or when the refractory metal is of the range as claimed in step a) of claim 48 and the nitride is of the range as claimed in step d) of claim 48. Applicant is requested to particularly point out the supporting portion from the specification. In particular, see the specification page 8 line 21 through page 9 line 9, page 12 line 23 to page 13 line 2, page 17 lines 10-15, 21 to page 18 line 6, page 19 lines 13-16, page 29 lines 13-16, page 40 Table A, page 42 lines 18-23, which do not provide support for the claimed ranges and greater thickness in question when taken in the context of the claimed ranges.

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

Claims 21-45 and 48-53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bai et al. in view of Ho et al., Hower et al., and Fu et al.

Bai et al. teach forming substrate 40, forming dielectric 41, patterning the dielectric layer to form trench 47, forming capturing layer 43 of titanium material having thickness between 5 Å and 500 Å, forming blocking layer of titanium nitride having thickness between 10 Å and 500 Å. See column 5 lines 1-33, column 8 lines 7-57, Fig. 3, column 10 lines 4-49. Note that the inventive feature of the capturing layer, the blocking layer, the refractory metal, the refractory metal nitride, and the layer thicknesses as characterized correspond to the claimed invention in claims 1-20 of Bai

et al., column 10 line 5 to column 12 line 32, e.g., claim 1 lines 4-11, claim 3 line 3, claim 4 line 3, claim 9 lines 1-4, claim 10 lines 4-12, claim 11 lines 3-5, claim 16 lines 1-13, claim 17 line 3, claim 18 line 3, claims 10 and 20 lines 1-4. The claimed parameters, e.g., thickness of less than 130 Å, width less than 3000 Å, aspect ratios greater than 3.33 is anticipated given the range taught in Bai et al. Note that the claimed metal nitride being of greater thickness than the refractory metal is not supported and sufficiently described as delineated above, and that such does not patentably distinguish over the teaching of the range in Bai et al., at portions delineated above, including and encompassing the blocking layer being of greater thickness than that of the capturing layer, e.g., column 10 lines 11-15, lines 48-50, lines 56-62. Any range and combined range claimed not anticipated by Bai et al. would have been obvious to one skilled in the art given the teachings of Bai et al., e.g., column 5 lines 6 et seq., to optimize the barrier thickness and to obtain the desired resistance of the interconnect. Any parameters not anticipated would have been obvious and would have been within the purview of one skilled in the art to obtain the desired trench width and aspect ratio.

The reference as applied above does not recite the plasma annealing of the titanium nitride barrier layer.

Ho et al. teach plasma reaction of titanium nitride in suitable gases, e.g., oxygen, nitrogen, to fill the grain boundaries hence improving barrier characteristics. See column 7 line 28 to column 8. The use of nitrogen or hydrogen as the gas to stuff the nitride is also taught. See column 7 lines 4-27, column 10 lines 3-20.

Hower et al. teach plasma treatment of titanium nitride in argon to reduce silicon movement therethrough and to reduce interface defects. See column 2 line 56 to column 3 line 30.

Fu et al. teach plasma treatment of titanium nitride in argon wherein the treatment smoothens the TiN and improves wettability. See column 2 line 48 to column 3 line 16.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the Bai et al. process to have employed plasma treatment of the titanium nitride since such is conventional and advantageous to improve barrier characteristics and wettability as taught by Ho et al., Hower et al., and Fu et al. It would have been obvious and would have been within the purview of one skilled in the art to have selected the desired conventional plasmas, the conventional electrical biasing and rf signal, to have employed single chamber for deposition and annealing, and to have employed conventional alternative metal nitrides. Alternatively, official notice is given regarding any conventional plasmas, alternative metal nitrides enumerated in the claims that are not recited above and the use of electrical biasing and rf signal as claimed.

Regarding claims 32-39 and 51, note further that Ho et al. teach the use of two anneals, e.g., first anneal of nitrogen and second anneal of hydrogen. See, e.g., column 7 lines 4-27, column 10 lines 8-20.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed two plasma anneals since such would permit the stuffing of the gases in the titanium nitride to improve barrier

characteristics. The use of gas plasma is conventional and advantageous wherein the plasma would increase the stuffing in the barrier material.

Claims 46 and 47 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bai et al. in view of Ho et al., Hower et al., and Fu et al. as applied to claims 21-45 and 48-53 above, and further in view of Dixit et al.

The references as applied above do not recite the upper metallization of tungsten.

Dixit et al. teach the filling of tungsten on the titanium/titanium nitride to complete the interconnection having low resistivity. See column 5 lines 3-57, column 7 line 34 to column 8 line 13.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed tungsten as interconnection since such is conventional and advantageous as taught in Dixit et al.

Claims 21-23 and 25-53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dixit et al. or Sandhu et al. taken with Suguro et al. and further in view of Ho et al., Hower et al., and Fu et al.

Dixit et al. teach forming channels 16 through insulating layer 14, forming titanium 19, e.g., about 100 Å, forming titanium nitride thereon, e.g., to about 250 Å using conventional deposition method. Well known alternative refractory metals and metal nitrides and alternative deposition techniques are also shown. See column 4 line 64 to column 7 line 11.

Sandhu et al. also teach forming channels 31 in insulating layer 32, forming titanium layer 35, forming titanium nitride barrier layer 41, forming tungsten or aluminum or copper thereon. See column 6 line 61 to column 7 line 33.

Suguro et al. teach the use of TiN as barrier layer wherein optimization of layer thickness of the titanium nitride is also taught, including the use of TiN thickness of 4 nm, 7 nm, and 10 nm; see the abstract, the paragraph bridging pages 280 and 281, wherein TiN thickness as low as 10 nm is employed.

Ho et al., Hower et all, and Fu et al. are applied as above.

It would have been obvious to one skilled in the art in practicing Dixit et al. or Sandhu et al. to have selected the desired thickness of the nitride barrier layer since such thickness variation and optimization are well within the purview of one skilled in the art as evidenced by Suguro et al., including the selection of the thickness of less than 13 nm, given the thickness taught by Suguro et al. The claimed parameters, e.g., thickness of less than 130 Å, thus would have been obvious given the range taught in Suguro et al. The use of thin adhesion layer, including adhesion that is thinner than the barrier layer, employing conventional processing woud have been obvious given the teaching of Dixit et al., wherein such thickness optimization would have been obvious and would have been within the purview of one skilled in the art. The use of alternative refractory metals and metal nitrides and the use of conventional deposition methods would have been obvious and would correspond to conventional materials and deposition and planarization process and such would have been within the purview of one skilled in the art. The selection of high aspect ratio and reduced submicron trench

width and of etchback of the respective layers to the extent desired to form plugs employing conventional processing is well known in the art and is well within the purview of one skilled in the art and as such would have been obvious.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed plasma treatment of the titanium nitride since such is conventional and advantageous to improve barrier characteristics and wettability as taught by Ho et al., Hower et al., and Fu et al. It would have been obvious and would have been within the purview of one skilled in the art to have selected the desired conventional plasmas, the conventional electrical biasing and rf signal, to have employed single chamber for deposition and annealing, and to have employed conventional alternative metal nitrides. Alternatively, official notice is given regarding any conventional plasmas, alternative metal nitrides enumerated in the claims that are not recited above and the use of electrical biasing and rf signal as claimed.

Regarding claims 32-39 and 51, note further that Ho et al. teach the use of two anneals, e.g., first anneal of nitrogen and second anneal of hydrogen. See, e.g., column 7 lines 4-27, column 10 lines 8-20.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed two plasma anneals since such would permit the stuffing of the gases in the titanium nitride to improve barrier characteristics. The use of gas plasma is conventional and advantageous wherein the plasma would increase the stuffing in the barrier material.

Applicant's arguments with respect to claims 1-23 and 25-53 have been considered but are moot in view of the new ground(s) of rejection.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Quach whose telephone number is 703-308-1096. The examiner can normally be reached on M - F from 9 to 5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri, can be reached on (703) 306-2794. The fax phone number for the organization where this application or proceeding is assigned is 703-308-7722.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Tuan Quach
Primary Examiner